

Modelling Risks with Full Monte

John Owen
Barbecana Inc.

Learning Objectives for this document

- **Estimate Uncertainty vs Risks**
- **Understand how risk can be modelled in schedules using Full Monte.**
- **Probability of Existence vs Discrete Risks**
- **Using Probabilistic Branching**

Introduction

Schedule Risk Analysis encompasses two separate techniques for creating more realistic models that consider the impact of uncertainty.

It is unfortunate that many start out with the assumption that Schedule Risk Analysis means that all threats need to be identified and included in the schedule. However, in practice, the bigger hidden threat to the project is usually **estimate uncertainty**. Even if estimates are excellent (meaning that on average the work will be completed in the time estimated), because all estimates are subject to some uncertainty, a factor called **Merge Bias** will reduce the chance of the project being completed on time.

Estimate Uncertainty (aka Epistemic – a lack of knowledge about the future).

Estimate Uncertainty stems from the fact that we cannot exactly predict how long tasks will take in the future. We may be extremely confident in an estimate, but we can never know *exactly* how long it will take until the work is complete. Estimate Uncertainty is often responsible for unexpected late delivery due to Merge Bias and is modelled using Three Point Estimates for task duration and resource rates. Estimate Uncertainty is not discussed further in this document.

Risks - Threats and Opportunities (aka Aleatoric – random events).

These are the events (risks) that may, or may not, occur. They are subject to random chance and will have varying impacts on the schedule. Each risk should be itemized in a Risk Register and a response to the risk agreed. Usual responses types are: Avoid, Mitigate, Transfer, Accept.

The potential impact of these risks to cost and schedule can be assessed using Full Monte to help determine an appropriate response type.

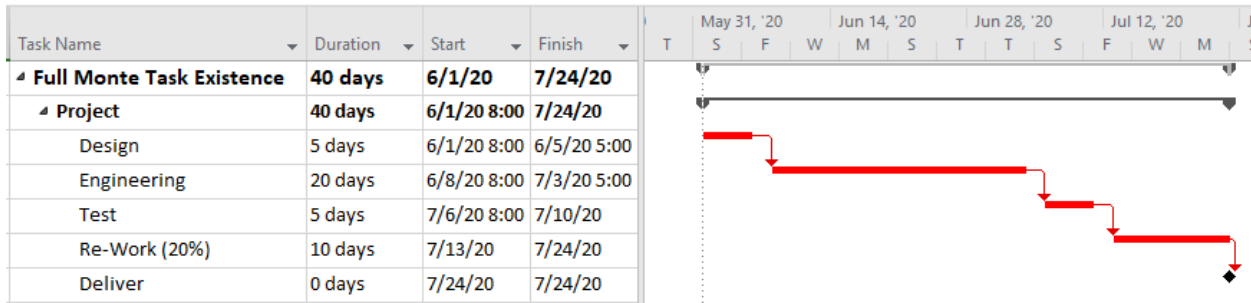
Full Monte has three mechanisms to model risks in schedules: **Probability of Existence**, **Discrete Risks**, and **Probabilistic Branching**.

Note: It is usually not appropriate to attempt to model specific risk events, that may or may not occur, using Estimate Uncertainty (Three Point Estimates).

Probability of Existence

Probability of Existence allows us to specify how likely it is that an individual task will occur. During the simulation, if the task is deemed to have not occurred then it will be treated as a zero-duration task with no cost impact.

Consider the following schedule:



The plan is showing that, following Design and Engineering, Testing will be performed. If Testing fails, an additional Re-Work of 10 days will be required. It is estimated that there is a 20% chance of the Re-Work being required.

Note: The Re-Work task can be marked as Inactive in Microsoft Project Professional, so the potential additional work does not affect the forecast finish shown by Microsoft Project.

After opening the schedule in Full Monte, we can set the Probability of Existence for the Re-Work task.

| ID | Task Name | Remaining Duration | Duration Distribution Type | Duration Optimistic | Duration Most Likely | Duration Pessimistic | Finish Histogram | Probability of Existence (%) |
|----|---------------------------|--------------------|----------------------------|---------------------|----------------------|----------------------|------------------|------------------------------|
| 0 | Full Monte Task Existence | 40 days | Triangular | 75% | 100% | 125% | NA | 100% |
| 1 | Project | 40 days | Triangular | 75% | 100% | 125% | NA | 100% |
| 2 | Design | 5 days | Triangular | 75% | 100% | 125% | NA | 100% |
| 3 | Engineering | 20 days | Triangular | 75% | 100% | 125% | NA | 100% |
| 4 | Test | 5 days | Triangular | 75% | 100% | 125% | NA | 100% |
| 5 | Re-Work (20%) | 10 days | Triangular | 75% | 100% | 125% | NA | 20% |
| 6 | Deliver | 0 | Triangular | | | | NA | 100% |

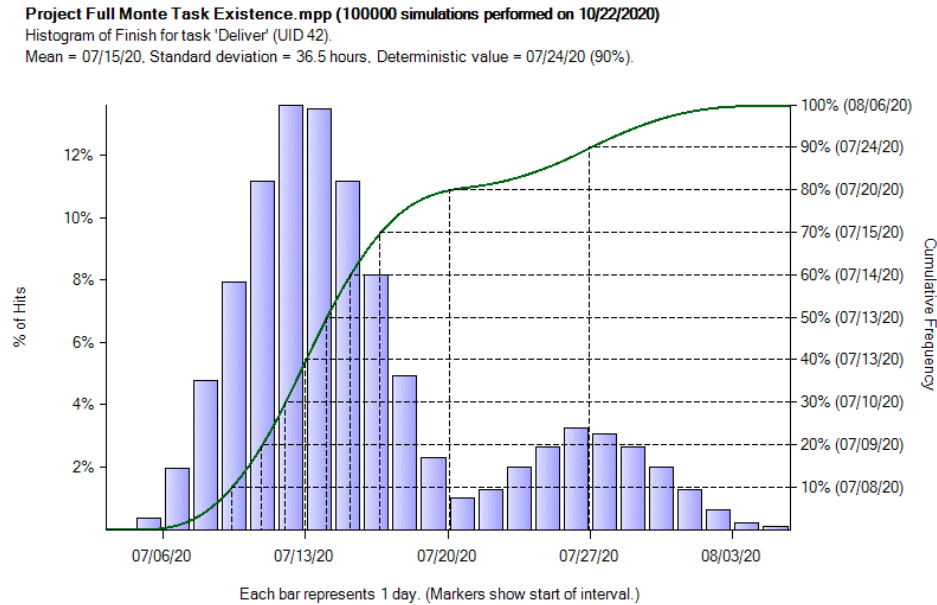
Re-Work (20%)
 Distribution Type: Triangular
 Enter the distribution parameters either as absolute durations or as percentages of the deterministic remaining duration, which is 10 days.
 Optimistic: 7.5 days or 75%
 Most likely: 10 days or 100%
 Pessimistic: 12.5 days or 125%
 Confidence interval (%): 100%
 Correlation: Existence Branching
 Select Discrete Risk ID: (None)
 ... or Existence Probability (%): 20%
 Apply Changes
 Help Cancel

The Probability of Existence initially defaults to 100% (or 0% for Inactive tasks in Full Monte 3.4) but can be modified in either the Edit Pane to the right of the view (click Existence) or by inserting Probability of Existence as a column in the table as shown.

In the example, the Probability of Existence for the Re-Work has been set to 20%.

Duration Uncertainty has been applied to all tasks.

The resultant probability distribution histogram for task 'Deliver' is shown here:



The histogram clearly shows a Bi-Modal (two humps) distribution. The first peak shows the range of finish dates when the risk did not occur, and the second peak shows the range of finish dates when the risk occurred.

Since the project will be delayed 20% of the time, by the risk occurring, the 80th percentile finish is halfway between the peaks and shows an 80% Confidence Finish of 7/20/20.

If we save the 80th Percentile dates back to Microsoft Project custom fields, we can create a Risk Adjusted Gantt view as shown here:

| Task Name | Duration | Start | Finish | Percent Critical | Start Percentile (80%) | Finish Percentile (80%) |
|---------------------------|----------|-------------|-------------|------------------|------------------------|-------------------------|
| Full Monte Task Existence | 40 days | 6/1/20 | 7/24/20 | 100 | 6/1/20 8:00 AM | 7/20/20 8:50 AM |
| Project | 40 days | 6/1/20 8:00 | 7/24/20 | 100 | 6/1/20 8:00 AM | 7/20/20 8:50 AM |
| Design | 5 days | 6/1/20 8:00 | 6/5/20 5:00 | 100 | 6/1/20 8:00 AM | 6/8/20 1:01 PM |
| Engineering | 20 days | 6/8/20 8:00 | 7/3/20 5:00 | 100 | 6/8/20 1:02 PM | 7/7/20 4:07 PM |
| Test | 5 days | 7/6/20 8:00 | 7/10/20 | 100 | 7/7/20 4:08 PM | 7/14/20 4:24 PM |
| Re-Work (20%) | 10 days | 7/13/20 | 7/24/20 | 20 | 7/14/20 4:07 PM | 7/29/20 8:42 AM |
| Deliver | 0 days | 7/24/20 | 7/24/20 | 100 | 7/20/20 8:50 AM | 7/20/20 8:50 AM |

The Purple milestone marker against 'Deliver' shows the 80% Confidence finish for the project.

Summary: Using the Full Monte Probability of Existence is a simple way to model a risk that can be represented by a single task. If modelling the impact of a risk occurring will require more than one task, then use Full Monte's Probabilistic Branching as described later in this document.

Discrete Risks

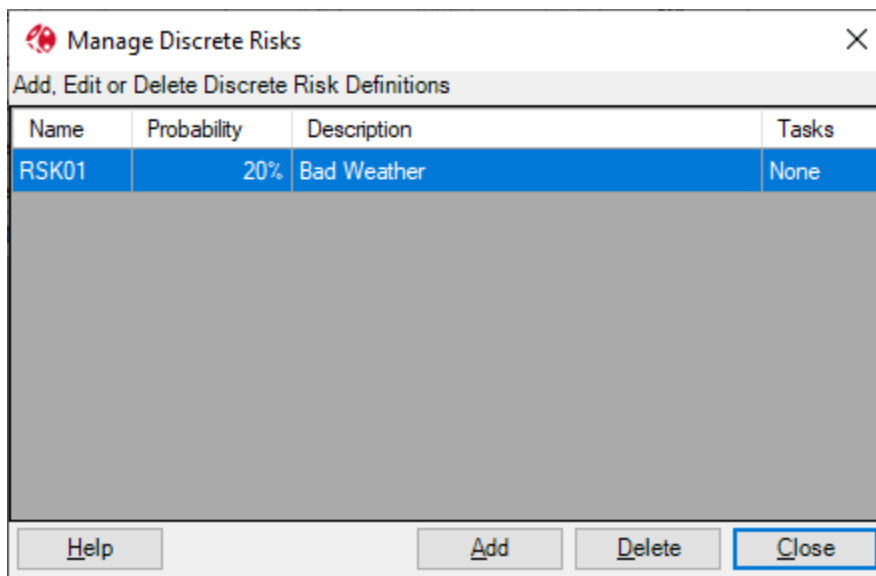
For the case where a single risk will affect multiple tasks in the schedule, Full Monte has a feature called Discrete Risks. Consider the following example schedule:

| Task Name | Duration | Start | Finish |
|---------------------------|----------|-------------|---------|
| Full Monte Task Existence | 30 days | 6/1/20 | 7/10/20 |
| Project | 30 days | 6/1/20 8:00 | 7/10/20 |
| Building A | 20 days | 6/1/20 8:00 | 6/26/20 |
| Weather Delay | 10 days | 6/29/20 | 7/10/20 |
| Building B | 20 days | 6/1/20 8:00 | 6/26/20 |
| Weather Delay | 10 days | 6/29/20 | 7/10/20 |
| Deliver | 0 days | 7/10/20 | 7/10/20 |

Buildings A and B each have a risk of being delayed due to weather. We estimate the delay will occur 20% of the time.

We could use the Probability of Existence on the Weather Delay tasks as described earlier however doing so would make the risks independent. During the simulation, Building A completion might be delayed in a particular iteration while Building B was not. If the two buildings are at the same site, we might expect bad weather to delay both at the same time. This is where we use Discrete Risks.

On the Full Monte **Edit menu** you will find **Manage Risks**.



This allows us to define specific discrete risks and their probability of occurring. In the above example, risk RSK01 has been defined as representing 'Bad Weather' with a 20% probability of occurring.

We can then assign the risk to multiple tasks in the schedule. In the following screenshot we have assigned RSK01 in the right hand edit pane by selecting it from the drop list of available risks. We then see the probability of existence is grayed out but displays the probability inherited from RSK01.

Full Monte Task Existence.mpp - Full Monte View: Task Edit (Customized)

File Edit View Help Risk Analysis Graphs Search for Name or ID >>

| ID | Task Name | Remaining Duration | Duration Distribution Type | Duration Optimistic | Duration Most Likely | Duration Pessimistic | Finish Histogram | Probability of Existence (%) |
|----|---------------------------|--------------------|----------------------------|---------------------|----------------------|----------------------|------------------|------------------------------|
| 0 | Full Monte Task Existence | 30 days | Triangular | 75% | 100% | 125% | NA | 100% |
| 1 | Project | 30 days | Triangular | 75% | 100% | 125% | NA | 100% |
| 2 | Building A | 20 days | Triangular | 75% | 100% | 125% | NA | 100% |
| 3 | Weather Delay | 10 days | Triangular | 75% | 100% | 125% | NA | 20% (RSK01) |
| 4 | Building B | 20 days | Triangular | 75% | 100% | 125% | NA | 100% |
| 5 | Weather Delay | 10 days | Triangular | 75% | 100% | 125% | NA | 20% (RSK01) |
| 6 | Deliver | 0 | Triangular | | | | NA | 100% |

7 rows | No Filter | No Highlight | Sorted on ID | Simulations: Risk Analysis Required

Weather Delay

Distribution Type: Triangular

Enter the distribution parameters either as absolute durations or as percentages of the deterministic remaining duration, which is 10 days.

Duration or Percent

Optimistic: 7.5 days or 75%

Most likely: 10 days or 100%

Pessimistic: 12.5 days or 125%

Confidence interval (%): 100%

Correlation Existence Branching

Select Discrete Risk ID: RSK01

... or Existence Probability (%): 20%

Apply Changes

Help Cancel

During the risk analysis, risk RSK01 is simulated to occur 20% of the time and when it does, every task with which it is associated will occur. This effectively correlates the probability of existence of all associated tasks at 100%.

It is important to note that the **impact** of the risk is not correlated by default which means, in this example, that although a Weather Delay will affect both buildings in the same iteration of the simulation, the impact to each may vary depending on the duration uncertainty applied to the risk task. If you wish the impact to be the same for each building, then you must also correlate the duration uncertainty as shown here:

| ID | Task Name | Remaining Duration | Duration Distribution Type | Duration Optimistic | Duration Most Likely | Duration Pessimistic | Finish Histogram | Probability of Existence (%) | Duration Correlations |
|----|---------------------------|--------------------|----------------------------|---------------------|----------------------|----------------------|------------------|------------------------------|-----------------------|
| 0 | Full Monte Task Existence | 30 days | Triangular | 75% | 100% | 125% | NA | 100% | |
| 1 | Project | 30 days | Triangular | 75% | 100% | 125% | NA | 100% | |
| 2 | Building A | 20 days | Triangular | 75% | 100% | 125% | NA | 100% | |
| 3 | Weather Delay | 10 days | Triangular | 75% | 100% | 125% | NA | 20% (RSK01) | RSK01 (100%) |
| 4 | Building B | 20 days | Triangular | 75% | 100% | 125% | NA | 100% | |
| 5 | Weather Delay | 10 days | Triangular | 75% | 100% | 125% | NA | 20% (RSK01) | RSK01 (100%) |
| 6 | Deliver | 0 | Triangular | | | | NA | 100% | |

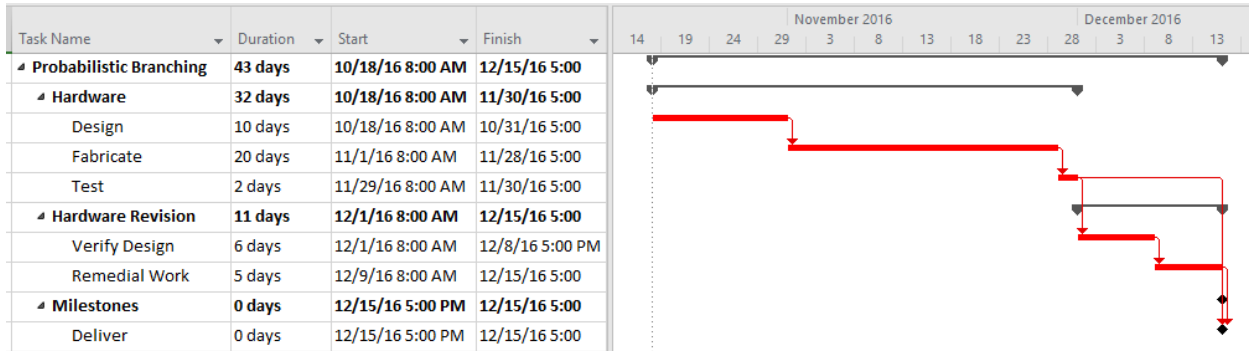
Note: For clarity we named the Duration Correlation Source RSK01 but this is not required.

Summary: Discrete Risks allow us to correlate the occurrence of tasks representing the impact of risks to multiple tasks in each iteration of the simulation. Duration Correlation allows us to specify the duration impact will be the same for each correlated task in each iteration of the simulation.

Probabilistic Branching

If modelling a risk impact will require multiple tasks, then the simplest solution is to use Full Monte Probabilistic Branching. Probabilistic Branching can be applied to any task that has two or more successors. We can then set the probability of execution for each successor.

In the following example, if the Test after Design, Fabricate fails then Verify Design and Remedial Work will both have to be carried out before Delivery.



In Microsoft Project we have created additional logic that shows either Verify Design or Deliver will follow Test. We estimate a 20% chance that the additional Verify Design and Remedial work will need to be performed. The following screenshot shows the successors for each task. We can see that Task 5 (Test) has successors of both Task 7 (Verify design) and Task 10 (Deliver).

| | Task Name | Duration | Start | Finish | Successors |
|----|---------------------------|----------|------------------|-----------------|------------|
| 1 | ▲ Probabilistic Branching | 43 days | 10/18/16 8:00 AM | 12/15/16 5:00 | |
| 2 | ▲ Hardware | 32 days | 10/18/16 8:00 AM | 11/30/16 5:00 | |
| 3 | Design | 10 days | 10/18/16 8:00 AM | 10/31/16 5:00 | 4 |
| 4 | Fabricate | 20 days | 11/1/16 8:00 AM | 11/28/16 5:00 | 5 |
| 5 | Test | 2 days | 11/29/16 8:00 AM | 11/30/16 5:00 | 10,7 |
| 6 | ▲ Hardware Revision | 11 days | 12/1/16 8:00 AM | 12/15/16 5:00 | |
| 7 | Verify Design | 6 days | 12/1/16 8:00 AM | 12/8/16 5:00 PM | 8 |
| 8 | Remedial Work | 5 days | 12/9/16 8:00 AM | 12/15/16 5:00 | 10 |
| 9 | ▲ Milestones | 0 days | 12/15/16 5:00 PM | 12/15/16 5:00 | |
| 10 | Deliver | 0 days | 12/15/16 5:00 PM | 12/15/16 5:00 | |

In the following screenshot we can see how to specify the chance of each successor being followed during the analysis.

FM 2017 Probabilistic Branching.mpp - Full Monte View: Task Edit (Customized)

File Edit View Help Risk Analysis Graphs Search for Name or ID >>

| ID | Task Name | Remaining Duration | Duration Distribution Type | Duration Optimistic | Duration Most Likely | Duration Pessimistic |
|----|-------------------------|--------------------|----------------------------|---------------------|----------------------|----------------------|
| 0 | Probabilistic Branching | 43 days | Triangular | 90% | 100% | 110% |
| 1 | Probabilistic Branching | 43 days | Triangular | 90% | 100% | 110% |
| 2 | Hardware | 32 days | Triangular | 90% | 100% | 110% |
| 3 | Design | 10 days | Triangular | 90% | 100% | 110% |
| 4 | Fabricate | 20 days | Triangular | 90% | 100% | 110% |
| 5 | Test | 2 days | Triangular | 90% | 100% | 110% |
| 6 | Hardware Revision | 11 days | Triangular | 90% | 100% | 110% |
| 7 | Verify Design | 6 days | Triangular | 90% | 100% | 110% |
| 8 | Remedial Work | 5 days | Triangular | 90% | 100% | 110% |
| 9 | Milestones | 0 | Triangular | 90% | 100% | 110% |
| 10 | Deliver | 0 | Triangular | | | |

Test

Distribution Type: Triangular

Enter the distribution parameters either as absolute durations or as percentages of the deterministic remaining duration, which is 2 days.

Duration or Percent

Optimistic: 1.8 days or 90%

Most likely: 2 days or 100%

Pessimistic: 2.2 days or 110%

Confidence interval (%): 100%

Correlation Existence **Branching**

Probabilistic

| Successor | Probability |
|-------------------|-------------|
| 10 (Deliver) | 80 |
| 7 (Verify Design) | 20 |

Apply Changes

Help Cancel

11 rows | No Filter | No Highlight | Sorted on ID | Simulations: Risk Analysis Required

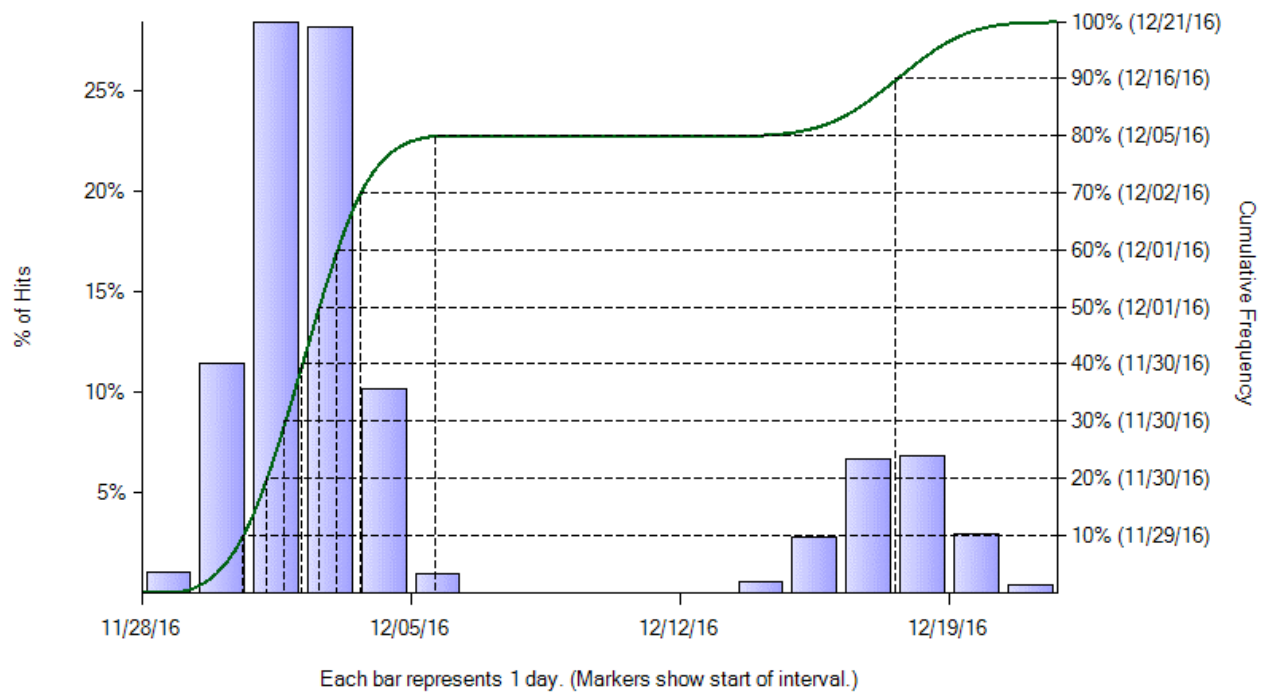
From test, we have entered an 80% chance that the logic will be followed to Deliver and a 20% chance that the logic will be followed to Verify Design.

When we review the probability distribution histogram for the task Deliver, we again see the characteristic multi-modal histogram created when conditional logic/tasks exist. 80% of the simulation finished between 11/28 and 12/5 while the remaining 20% of the simulations finished between 12/14 and 12/20.

Project FM 2017 Probabilistic Branching.mpp (10000 simulations performed on 10/22/2020)

Histogram of Finish for task 'Deliver' (UID 5).

Mean = 12/05/16, Standard deviation = 36 hours, Deterministic value = 12/15/16 (90%).



As 80% of the simulations finished by 12/5, the 80th percentile on the S-Curve is 12/5.

Summary: Probabilistic Branching allows risks (**Threats**) that comprise multiple tasks and additional logic to be modelled. Probabilistic Branching can also be used to model logic representing **Opportunities**.

Note: **Conditional Branching** is covered in a separate document. Conditional Branching is best suited to modelling **Risk Mitigation strategies**.

Suggested Reading from our 'How to...' Documents

Why and how to use Conditional Branching

Sensitivity and Risk Path Analysis

The Duration Confidence Interval Explained (and why not to use it)

Interpreting SRA Results

<https://www.barbecana.com/full-monte/full-monte-documents/>